Building Research Establishment Digest

CI/SfB 1976 (21) (L3)

DIGEST 245

January 1981

Rising damp in walls: diagnosis and treatment

This digest considers the causes of dampness in walls and offers a positive method for diagnosis of rising damp. It suggests possible remedial measures which can be taken to avoid rising damp such as providing a complete moisture barrier by insertion of a physical damp-proof course or the non-traditional method of chemical injection. The repair of areas of plastering damaged by damp is also included. This digest replaces Digest 27 which is now withdrawn.

Masonry walls which stand in water or in saturated soil and which contain no physical barrier to the upward flow of moisture, often have rising damp at heights in excess of 1 m. This height depends on several factors, such as the pore structure of the wall, the degree of saturation of the soil, the rate of evaporation from the wall surfaces and the presence of salts in the wall. Bricks and mortars have a complex pore structure in which the diameter of the pores varies widely, as does the pore size distribution in each component. This has an important effect on the height to which the damp will extend because, within limits, the smaller the pores the greater the vertical rise of moisture. Old walls may contain pores as small as 0.001 mm diameter, which can theoretically support a column of water far higher than 1 m.

For water to rise in a wall, a supply must be available at the base. If the ground surrounding the wall is saturated, this condition is achieved but if the ground is not saturated the soil will exert a suction that will oppose the upward capillary pull on the water in the wall. This suction is approximately equivalent to the negative pressure exerted by a column of water extending from the base of the wall to the water table. If the water table falls the height of the moisture in the wall will drop to a new level provided there is sufficient time for equilibrium to become established. Each period of heavy rain on the base of the wall will produce a temporary condition of saturation and the water level in the wall will begin to rise again. The level to which is rises depends on the amount of evaporation of water from a wet wall and on the resistance to the flow of moisture up the wall. If this resistance is high, as in a material with many fine pores, the effect of evaporation is most marked but if the wall material has many coarse pores, the height of dampness will be only slightly affected by normal rates of evaporation. Increasing the heat input to the structure will increase the rate of evaporation from the wall surfaces. The overall effect is to increase the rate of flow of water up the wall but because of the resistance to flow this is likely to be accompanied by a reduction in the height to which the moisture extends. In addition, evaporation will occur from deeper in the pores of the plaster so that the rising damp seems to disappear. In summer, hot weather will increase the evaporation rate and lower the water table so the effect on rising damp can be even more striking.

Water drawn from the soil usually contains a low concentration of soluble salts and the rising water will also generally dissolve salts from the bricks or the mortar. These salts tend to increase the surface tension of the water which increases the upward pull but this will be partially offset by the increase in density of the solution and the consequent increased downward pull of gravity. When evaporation occurs the salt solution becomes more concentrated at the surface and finally the salts will crystallise out. This tends to block the pores, reducing evaporation and hence raises the level of dampness. These salts may also be hygroscopic and will absorb moisture from the air above some critical value of relative humidity so that the surface appears wet during wet weather although this dampness seems to disappear when the air becomes drier again.

All this suggests that under real, dynamic conditions rising damp in a wall is often in a rather sensitive equilibrium which may be considerably disturbed by changes in the heating of the building and in the level of the water table. The presence of hygroscopic salts tends to obscure any drying associated with such changes by keeping the wall more moist than it would otherwise be. If such salts are removed from the surface by removing the old plaster, and the heating system is improved, it is likely that the apparent dramatic improvement in the appearance of the wall surface will give the impression that the rising damp has been cured. It is against this background that the correct diagnosis of rising damp becomes important.

Prepared at Building Research Station, Garston, Watford, WD2 7JR
Technical enquiries arising from this Digest should be directed to Building Research Advisory Service at the above address.

Diagnosis

Because of high remedial costs, it is essential that the diagnosis is as positive as possible to distinguish between rising damp and other sources of dampness. The presence of damp that has existed for some time is indicated by clearly visible signs such as damp patches on walls, peeling and blistering wall decorations, patches of efflorescence and possible rotting and splitting woodwork due to wet or dry rot. There is usually a damp and musty smell due to mould growth. Many of these visible signs may be absent if the dampness problem has recently developed or is caused by an intermittent and occasional source of damp such as rain penetration or condensation. The presence of rising damp is often indicated by a horizontal tide mark at a height of 1 m or so along a wall (Fig 1). However, the visible signs do not necessarily indicate the cause of the problem as there are a number of possible causes other than rising damp. They include:

(a) rain penetration through defects in construction or materials or leaking gutters or downpipes;

(b) water from defective plumbing systems and drains;

(c) condensation;

(d) contamination of surfaces by hygroscopic salts;

(e) water used in construction.

Penetrating damp from some external source is likely to create isolated patches of dampness that increase in size after periods of heavy rain and tend to disappear in long dry spells of weather. The patches may be near or well away from floor level on external walls. Where there is dampness, a close inspection should be carried out to ensure that water is not penetrating from such external sources. Time must be allowed after any remedial measures for the damp structure to dry (6 to 12 months) before seeking other causes of dampness.

Condensation may occur from the way in which a building is used or because of the design of the structure itself. Poor ventilation, low temperatures and the heavy use of such devices as paraffin heaters for local heating can raise the moisture content of the air to the point where the moisture condenses out on to any available cold surface. Serious condensation gives rise to large amounts of moisture running down non-absorbent surfaces such as single-glazed windows. On absorbent wall surfaces the condensation results in large damp areas which can support mould growth.

Moisture will move through a structure towards the surfaces where evaporation is taking place. The moisture will carry with it soluble salts either introduced with the moisture or already present in the structure. Salts will therefore concentrate on wall surfaces, regardless of the source of moisture that carries them there, and cause efflorescence. Old plasters tend to become contaminated with salts but this does not necessarily mean that rising damp is the cause. These salts might be hygroscopic and in absorbing moisture from the air, produce a damp wall surface. If non-hygroscopic, the salts will be unsightly and damage decoration but will not cause damp patches. The presence of hygroscopic salts does not necessarily indicate rising damp as the cause. However, rising damp usually concentrates hygroscopic salts on wall surfaces; these salts are mainly carried up from the foundations and surrounding soil (Fig 2).

Large amounts of moisture will be introduced into a newly built structure or into an existing dwelling subject to new extension work. This is an inevitable consequence of the building process which presents no long-term problems provided there is adequate ventilation and heating to allow the structure to dry.

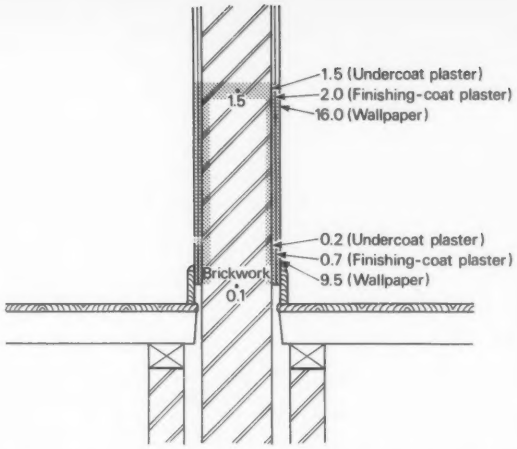


Fig 2 Concentration of salts in a party wall in which rising damp has persisted for 80 years. Figures show percentage, by weight, of chloride plus nitrate. The shaded area is heavily contaminated.

Fig 1 Rising damp

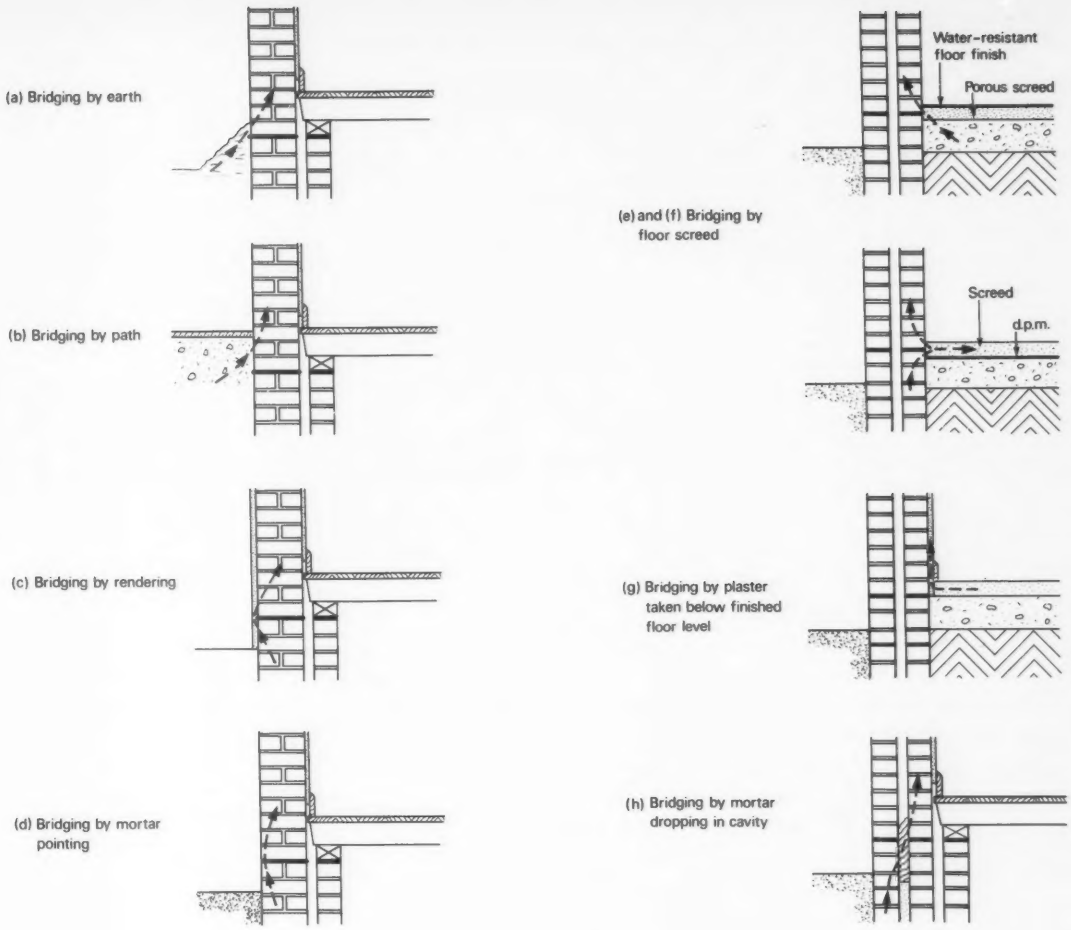

(a) Bridging by earth
(b) Bridging by path
(c) Bridging by rendering
(d) Bridging by mortar pointing
Water-resistant floor finish
Porous screed
(e) and (f) Bridging by floor screed
Screed
d.p.m.
(g) Bridging by plaster taken below finished floor level
(h) Bridging by mortar dropping in cavity

Fig 3 Bridging of damp-proof course.

Rising damp must, by definition, create moisture and a moisture gradient in the height and thickness of a structure, not merely surface moisture. The existence of such a gradient should be demonstrated before deciding whether or not a damp-proof course is really necessary. In many situations where rising damp occurs, it is often due to the bridging of an existing damp-proof course rather than the absence of one (Fig 3). Measurements of surface moisture are in themselves no indication that a genuine rising damp problem exists. The electrical meters commonly used by surveyors are responsive to both the amount of moisture present and to the salt concentration and are incapable of distinguishing between the two. Such meters quite commonly give high readings on the walls of old properties where some accumulation of salts inevitably occurs on internal surfaces. This does not mean, however, that the property necessarily has a dampness problem; high readings can be obtained from a wall where the concentration of salts is high, even if the wall is virtually dry. Nevertheless, as preliminary surveying instruments, these meters have a valuable role to play and will identify areas where further investigation is necessary.

To obtain more conclusive proof of the presence of rising damp the most satisfactory approach currently available is to obtain samples of the bricks, blocks or mortar at some depth in the wall. From these samples an accurate measurement of the moisture content of the wall can be obtained, together with an indication of the influence of any hygroscopic salts that may be present. The sampling technique, which is described in the Appendix, creates a limited amount of dust and slight damage to decorations. A wrong diagnosis could, however, lead to considerable unnecessary expenditure.

Interpretation of results

It is unusual for walls with moisture contents less than 5 per cent at their base to be severely affected by rising damp, though hygroscopicity caused by salts which may have migrated over many years can cause damage to the plaster and decorations.

Comparing the hygroscopic moisture content (HMC) with the moisture content as found (MC) gives an indication of which factor is controlling the dampness at any position. An HMC higher than the MC indicates that the dampness is due to moisture from the air rather than from the ground or some other source. An MC higher than the HMC indicates that water is coming from some source other than the air, such as rising damp or rain penetration.

If samples are taken at a sufficient number of heights the results can be plotted as shown in Figure 4 which illustrates two typical cases of rising damp where the moisture content is more than 5 per cent at the base of the wall and decreases with height.

Figure 4 (a) illustrates a situation where the moisture content in the lower part of the wall is dominated by rising damp above which there is a region in which the moisture content is controlled by the hygroscopicity of the wall. Figure 4 (b) illustrates a situation where the conditions at the base are similar to 4 (a) but where the upper region of the wall is gaining water from other sources, eg driving rain; the moisture content of the upper portion is above that due to any hygroscopic salts present and no significant moisture gradient exists.

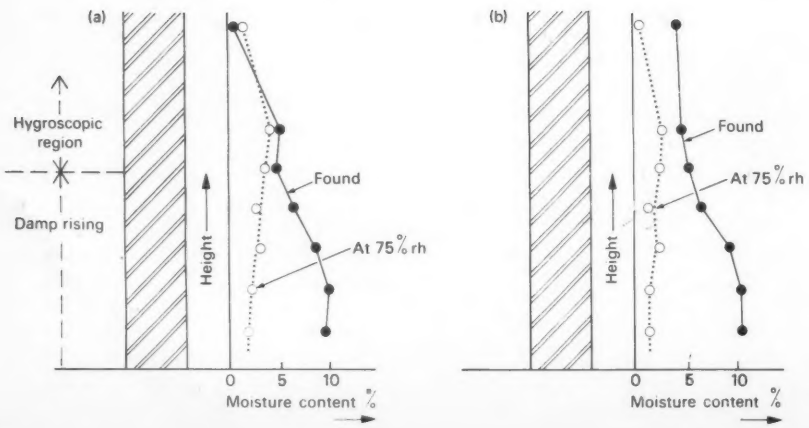
It is not possible to list all the various moisture gradient profiles that can be obtained in this way but several important points need to be emphasised as a guide to interpretation.

Experience has shown that some building materials possess an HMC of up to 5 per cent even without the introduction of salts from external sources. Although only a rough indicator, the 5 per cent threshold does represent a reasonable general guide to whether or not some kind of remedial treatment is needed. This emphasises the importance of the difference between the HMC and MC measured on samples.

If only rising damp is present, there should be a definite moisture gradient from the base of a wall tapering off to a point where the HMC becomes equal to the MC. Other sources of moisture to a wall (eg rain penetration) will alter this gradient so that a precise diagnosis of rising damp cannot be made. It is important therefore to remedy other causes and allow time for remedial measures to take effect.

Rising damp is a seasonal effect, increasing in winter with rising water tables and falling in summer. This seasonal effect must be taken into account in any diagnosis since the problem could disappear in the summer months and return in the winter.

Fig 4 Results from typical cases.



Treatment

Where rising damp has been diagnosed, treatment will involve either curing the source of the problem or masking its effects. Curing the problem at source is normally preferable and as a first step a building should be closely inspected to ensure that an existing damp-proof course is not being bridged. Earth piled against external walls should be removed and external render and internal plaster cut back to just above the dpc line. Improving the land drainage at the base of the wall may also help to cure the problem. In old houses with suspended wooden floors, the dpc usually runs in the mortar course at the top or bottom of the ventilation grills set in the external walls. The grills should be cleared of any obstruction since the presence of adequate sub-floor ventilation is most important. Suspended wooden floors should be checked for possible wet or dry rot. They may need extensive preservative treatment and the cutting out of any decayed timber. In many situations, the original dpc will be completely effective; a fact often overlooked when treatment is being considered.

The methods for installing a new dpc are described generally as 'traditional' (the insertion of a physical damp-proof course) or 'non-traditional'. It is strongly recommended that non-traditional methods should be considered only if they have been awarded an Agrement Certificate. The only one currently to satisfy this requirement is chemical injection. This is the only method which the Building Research Establishment considers suitable where insertion of a physical dpc is not possible. Physical dpc's can only be placed in brickwork or coursed stonework; random flint walls or rubble infilled walls are not suitable. Unusually thick walls can rarely be treated and it can be dangerous to attempt installations of this type for structural reasons if the walls have settlement cracks. Chemical injection systems can be used in most types of structure although flint walls and rubble infilled walls can be very difficult to treat successfully.

Where treatment of the source is virtually impossible, the alternative is simply to mask the effects of damp by using some kind of wall lining technique, such as plasterboard on battens or a proprietary system. This approach has the fundamental disadvantage that such remedies will cut down the evaporation rate from a wall and cause the dampness to rise further. Rising damp results from a dynamic equilibrium between the rate at which water is fed to the structure via the soil and the rate at which it evaporates away via air flow across the surfaces. Increasing the height and intensity of the dampness could pose serious longer-term dangers to wooden components such as window frames.

Physical damp-proof course

The only certain way in all circumstances of introducing an effective dpc into a wall is to insert a new physical membrane. Techniques for doing so have improved over recent years and the cutting of an old lime/sand mortar bed joint through the entire thickness of a 225 mm (9 inch) solid wall should, in most cases, present no problems.

A tungsten-carbide tipped chainsaw is usually used and the cut made in short lengths of about 1 m at a time. The membrane is loaded with mortar and inserted and temporary wedges used in the remaining gap to prevent settlement. Eventually the cut is back-filled with more mortar. In the standard solid 225 mm brick wall, the entire thickness of the wall can be cut from one side but, of course, great care has to be taken that all water and gas pipes and electrical wiring are moved out of the way. A new dpc, regardless of type, should if possible be inserted below the level of an existing suspended wooden floor and as close as possible to the top screed of an existing solid floor. Conditions vary enormously in this respect and usually some compromise is necessary in the siting of a new damp-proof course. Any gap between horizontal dpc and solid floor membrane should be closed if necessary with a tanking type of treatment.

The advantages of the physical techniques are that the membrane can be extended internally to form a vertical dpc between any solid floors and the horizontal course, and the membrane (usually flexible black polythene) is resistant to all acids and alkalis normally encountered in building materials. The disadvantages are cost, time taken and the disturbance created.

Chemical injection systems

These involve the use of silicone or aluminium stearate water repellents, either injected at high pressure or transfused into the wall under gravity or at low pressure. The high pressure systems are used most often with solvest-based silicones and aluminium stearates, whilst the transfusion methods are of necessity limited to the appliction of water-based silicones basically in the form of the water-soluble sodium methyl siliconate. The water-repellents are pore liners rather than pore blockers and hence allow the passage of some water vapour whilst preventing the rise of liquid moisture. The repellents are not intended to provide a damp-proof barrier against a substantial positive pressure of water and should not be used in basement areas subject to high water tables and penetrating damp. Another limitation is that the repellents in common use for damp-proofing work are not durable in the long term in highly alkaline conditions and their use is not recommended in newer buildings containing relatively fresh cement mortars. Available evidence suggests that high alkalinity is not a problem in older buildings with well weathered lime/sand mortar joints, unless perhaps the walls are exceptionally thick. Once injected, various curing and solvent evaporation processes occur resulting in polymerisation reactions and the weak bonding of the cured repellents to the material substrate. This bonding serves to keep the injected and cured material in place in the presence of active rising damp.

The efficiency of chemical injection systems depends on the efficiency of the fluid penetration of a damp structure. The repellents are injected or transfused into

closely spaced holes in brick or mortar courses along the dpc line and treatment must be carried out at different depths in anything other than a single leaf wall to ensure penetration through the entire thickness of the structure. The transfusion methods carried out at low pressures with aqueous repellents should, in principle, penetrate more effectively than the high pressure systems since they depend almost entirely on diffusion processes which are the only physical processes that can eventually give complete penetration. The disadvantages are that diffusion processes are extremely slow and the danger arises that the slow curing aqueous repellent can be carried away in the presence of very active rising damp before an effective dpc is formed. In practice it is unlikely that an injection treatment will create a completely impervious barrier in a truly damp wall. The success of these systems in treating a case of genuine rising damp lies in reducing the moisture flow up the wall to such an extent that the dampness problem in practical terms disappears.

The treatment of rising damp by various chemical injection systems is perhaps best summed up by the general statement that all injection techniques are likely to be less effective in non-uniform materials and where moisture contents are quite high at the injection level. Fortunately, in practice, the latter condition is rare: evidence suggests that most cases of genuine rising damp involve low enough moisture levels for an injection technique to have a significant effect. As rising damp is a seasonal effect, injections are best carried out in late summer when water tables are at their lowest and the walls are relatively dry.

Replastering

Where a dampness problem exists, it usually leads to damaged internal plaster-work and a subsequent need for some replastering as part of remedial treatment. The main requirement of any new plastering is that it should act as a barrier to residual salts and moisture in a wall. Ideally it should have as high a vapour permeability as possible to help the evaporation of residual moisture and should be weaker than the background to which it is applied. Gypsum-based undercoats are not effective moisture barriers and should not be used. The rich cement-based undercoats usually applied by installers are effective moisture barriers in their own right. However, their vapour permeability is low and their strength very high. Some recent tests on a typical 1:3 cement/sand undercoat finished with Class C Gypsum plaster have shown the finished surface to remain completely dry with an evaporative air flow across it even with water under a positive pressure behind the system. Although a washed and well-graded sand was used no waterproofing additives or workability aids were incorporated. Results of this sort demonstrate the possibilities of a basic cement/sand system as a moisture barrier although the disadvantage of high strength and low vapour permeability remain. High strength may preclude their use direct on very weak backgrounds where lathing is needed to provide a base for the plaster.

Further reading

Installation of Chemical Damp Proof Courses, British Chemical Dampcourse Association Code of Practice, 1978.

BRE Digests

18 Design of timber floors to prevent decay
54 Damp-proofing solid floors
77 Damp-proof courses
89 Sulphate attack on brickwork
110 Condensation
125 Colourless treatments for masonry
163 Drying out buildings
198 Painting walls - Part 2: Failures and remedies

The Agrement Board PO Box 195, Bucknalls Lane, Garston, Watford, Herts.

APPENDIX

The sampling method

The basis is to drill samples from the wall and measure both their water content and hygroscopicity. Walls may contain considerable quantities of hygroscopic salts. Therefore, hygroscopicity should be measured to see whether the wall could have absorbed from the atmosphere the quantity of water found in the samples.

Location for test sampling

A damp location away from sources such as drains, dripping gutters or earth piled against walls should be chosen for examination. An internal wall is ideal if this appears to have rising damp. On external walls it is preferable to sample from the inside, though with a plastered wall this will usually require removal of small areas of plaster so that the mortar joints can be identified.

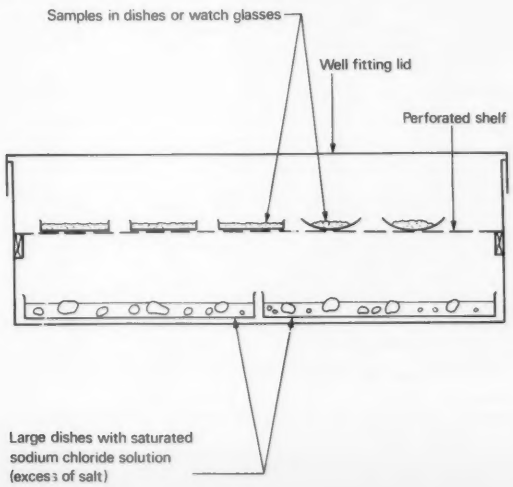
Collection of sample

A low-speed drill with a masonry bit of about 9 mm diameter is used. If the wall has mortar joints samples of the mortar should be taken, since in most cases the mortar will be wetter than the bricks. The outer 10 mm or so should be rejected, the sample being taken from 10 mm to about 80 mm depth. In brickwork, samples should be taken every two or three courses up to a level beyond the point where rising damp is suspected; it is usually worth taking at least one sample well above this height. The sample should be collected either in a small stoppered bottle for subsequent weighing or, if measuring moisture immediately in a carbide meter, in the scale pan provided. When using a carbide meter, part of the sample should be put aside for the hygroscopicity determination. The height of the drilled holes above ground level and position in the building should be measured and recorded. Tests have shown that the heat produced by drilling does not cause sufficient evaporation to affect significantly the accuracy if the drill bit is sharp and the material is not so hard as to make drilling difficult.

Measurement of moisture content and hygroscopicity of sample

The moisture content can be established either by a direct weighing and drying method or by a carbide meter. Tests have shown that a carbide meter gives an accurate measure of the water in a sample. The main advantage of the longer weighing method over a carbide meter is that is requires a smaller quantity (say one gram), whereas the minimum for the carbide meter is three grams. With the latter it is also necessary to keep separate samples for hygroscopicity measurement.

For most situations it is suitable to measure hygroscopicity at 75 per cent relative humidity; for most walls the effective relative humidity is less than 75 per cent and it is easy to provide a relative humidity of 75 per cent by using a saturated solution of common salt (Na Cl). A closeable vessel is required in which the sample can be placed over, but not in contact with, the solution of salt. A dessicator or an enclosed space similar to that shown in Fig 5 is suitable.


Samples in dishes or watch glasses
Well fitting lid
Perforated shelf
Large dishes with saturated sodium chloride solution (excess of salt)

Procedure using a balance

1 Collect the samples in stoppered bottles.

2 Shake the bottle well before removing stopper. Then spread about 2 grams of the sample from the bottle on to a previously weighed Petri dish or watch glass of about 40 mm diameter (weight W_o) and weigh immediately (weight W_w).

3 Place immediately in enclosure at 75 per cent relative humidity. Leave for a time: overnight should be sufficient if the layer is only 1 to 2 mm deep.

4 Reweigh (W_{75}).

5 Place in an oven at about 100°C for about an hour. Remove and allow to cool. Reweigh soon after cooling (weight W_d).

6 Calculate the following:

Hygroscopic moisture content at 75 per cent RH (HMC) =

$$100\ \frac{W_{75} - W_d}{W_{75} - W_o}\ \%\ \text{wet wt}$$

Moisture content of sample when found (MC) =

$$100\ \frac{W_w - W_d}{W_w - W_o}\ \%\ \text{wet wt}$$

This procedure cuts down weighing to a minimum, but if the moisture content is required more quickly, part of the sample may be left in the bottle or put out on an additional dish and the moisture content of that found by weighing and oven drying.

Procedure using a carbide meter

When only a carbide meter is used (with a minimum quantity M), the procedure is as follows:

1 Collect at least 2M of sample.

2 Shake bottle and weigh out a quantity M.

3 Measure moisture content of M in the carbide meter. (This moisture measurement may have been carried out on site).

4 Place the remainder in a Petri dish and leave in the 75 per cent enclosure for sufficient time to achieve equilibrium: about 2 days.

5 Weigh out a quantity M from the Petri dish and test in the carbide meter.

Equipment required

Electric drill with low speed for drilling masonry.

Masonry bits of 9 mm diameter.

Weighing bottles with well-sealed stoppers. (Identify by numbering with a scribe or felt marker).

Dish or chute to collect the powder sample.

A closeable vessel in which samples can be placed over, but not in contact with, a solution of salt (Fig 5).

Either

Laboratory balance accurate to ± 1 mg. (Alternatively, weighing facilities may be available locally at a school or technical college.)

Oven able to be controlled to about 100°C. (A lower temperature just prolongs the drying whereas temperatures of much more than 100°C may affect the sample chemically.)

Or

Carbide meter. In practice it may be an advantage to use both oven drying and the carbide method.

Fig 5 Enclosure with 75 per cent relative humidity.

Department of the Environment **Building Research Establishment**

© Crown Copyright 1981

Dmd.696669 ISBN 0 11 725078 3